TITLE OF THE INVENTION

SURROUND SOUND DISPLAY

BACKGROUND OF THE INVENTION

The current invention relates to displays of audio information, and more particularly to a surround sound display for displaying certain characteristics, such as amplitude and phase relationships, of multi-channel sound.

Correlation between two signals is a measure of how much alike the two signals are, expressed mathematically. If both signals are identical except for amplitude scaling, the correlation is positive and unity. If the signals are completely unrelated, the correlation is zero. A negative unity indicates that the signals are identical except for amplitude scaling, but of opposite polarity. Therefore the correlation between two signals may have any value between +1 and -1.

There have been attempts to give a visual indication of multi-channel sound characteristics. The Master Stereo Display MSD-600 with a CDR-1616 Digital Audio Matrix provides separate graphic and bar graph displays of multi-channel sound. Also the Leader 5836A Surround Audio Monitor displays a sound image of multi-channel sound for 3-1/3-2 types of surround audio systems. The MSD multichannel "jellyfish" display has no phase information, just relative amplitude between channels. The Leader multi-channel Lissajous-like display is useful, but very difficult to interpret — it does not give an easy to understand representation of the sound field.

What is desired is a surround sound display that gives a user a quick visual representation of a surround sound audio program in a single display for both amplitude and phase elements.

BRIEF SUMMARY OF THE INVENTION

Accordingly the present invention provides a surround sound display that gives a user a quick simple display of the phase and amplitude characteristics of a surround sound system. The display includes a sound stage image, using speaker images or symbols at appropriate locations on the display and a listener image in the center of the display. For each channel of a stereo pair a bent correlation meter scale, either visible or invisible, is used with a +1 correlation at one end of the scale situated at the center, a zero correlation in the middle of the scale at the corner, and a -1 correlation at the other end of the scale situated around the corner at approximately ninety degrees with respect to the listener image. Corresponding markers for the bent correlation meter scales are used to represent the amount of correlation between the channels of the stereo pair, the distance or "width" between the markers representing the correlation between the stereo channels. Brightness or color may be used as an indication of amplitude of each channel of the surround sound system, or wedges that extend toward the listener image may be used where the "height" of the wedges represents amplitude and the angular "width" represents phase.

The objects, advantages and other novel features of the present invention are apparent from the following detailed description when read in conjunction with the appended claims and attached drawing.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING

Fig. 1 is a graphic view display for a simple stereo system according to the present invention.

Figs. 2A, 2B and 2C represent an alternative graphic view display for different correlation values for the simple stereo system according to the present invention.

Fig. 3 is a graphic view display for the simple stereo system using an annular ring pattern according to the present invention.

Fig. 4 is a graphic view display for the simple stereo system using a ring angle pattern according to the present invention.

Fig. 5 is a graphic view display for the simple stereo system using a pie slice pattern according to the present invention.

Fig. 6 is a graphic view display for the simple stereo system using a rectangular pattern according to the present invention.

Fig. 7 is a graphic view display for a five channel surround sound system according to the present invention.

Fig. 8 is an alternative graphic view display for the five channel surround sound system according to the present invention.

Fig. 9 is a further alternative graphic view display for the five channel surround sound system according to the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Referring now to Fig. 1 a two-channel stereo system display is shown with Left and Right channels only. A "bent" correlation meter scale **12L, 12R** is associated with each channel in front of a speaker image **10L, 10R** for each channel at the upper corners of the display. Image "width" as represented by the distance between a pair of pointers **14L, 14R**, one for each correlation meter scale, is related to phase correlation between the channels. Fully correlated L and R channels produce a point image in the center of the "sound stage" represented by the speaker images **10L, 10R**, sometimes called a phantom center. As L and R correlation decreases, the distance between the markers **14L, 14R** widens until at zero correlation the pattern is as wide as the space between the speaker images. As correlation goes negative, the pattern or distance between the pointers **14L, 14R** extends outward around the "bend" beyond the speaker images **10L, 10R**.

Instead of the bent correlation meter scales **12L, 12R**, the space between the pointers **14L, 14R** may be filled in with bright or colored areas, as indicated in Figs. 2A, 2B and 2C for correlation values of 0.5, 0 and -1. Also the pattern may be filled or shaped differently as shown in Figs. 3-6 representing respectively (a) an annular ring pattern **18** for a

correlation value of -1, (b) a ring angle pattern **20** proportional to correlation for a correlation value of -0.5, (c) a pie slice pattern **22** for a correlation value of +0.3, and (d) a rectangular ring pattern **24** for a correlation value of -1.

In addition to phase correlation the pattern may indicate intensity or level as well either by means of brightness or color of "wedges" **26L, 26R, 26C, 26LS, 26RS** associated with each channel, or by turning the wedges into amplitude meters deflecting inward toward a "listener" **28** represented by a head image at the center of the display, as shown in Fig. 7 for a 5-channel system. The C (Center) channel wedge **26C** is fixed in location and width. Amplitude **A** is indicated by change in height toward the listener **28** in the center. The inner sides of the L and R wedges **26L, 26R** are fixed, but the outer sides move along an invisible or visible phase correlation meter scale **12L, 12R** to indicate correlation from +1 to -1 as shown. The amplitudes of the L and R signals are indicated by the heights of the wedges moving towards the listener. The wedges are essentially level bars whose width depends on phase correlation between the signals and whose height depends on the amplitudes of the individual signals. The same scheme is used for the Left Surround and Right Surround channels at the bottom of the display.

A variation of this scheme is shown in Fig. 8 where the zero correlation condition is indicated by wedges **26L, 26R** centered on left and right 45° axes. When correlation is positive, the wedges widen along the

correlation meter scales **12L, 12R** towards the center wedge **26C** while the opposite edge remains fixed. When correlation is negative, the edge away from the center wedge moves outward, widening the wedges toward the 90° axes while the edge toward the center remains fixed. In all cases the amplitude is indicated by the height of the wedge toward the listener. The same scheme is used for the Surround channels at the bottom of the display.

Another variation of this display, shown in Fig. 9, eliminates phase information altogether, showing only the amplitude relationships between channels. This pattern keeps the wedges at a fixed width, and the amplitude of each channel is shown by expanding the wedge height toward the listener at the center. This is essentially a circular bar graph. Optionally a wedge **26CS** for a "Low Frequency Enhancement" sixth channel, for 5.1 channel sound, may be added at the center rear between the Surround channel wedges **26LS, 26RS**.

These displays shown in Figs. 1-9 give a user a quick visual representation of a surround sound audio program. The displays of Figs. 7 and 8 offer in a single display both amplitude and phase elements critical to proper system monitoring. Phase reversals, radical unbalance or missing channels are immediately evident. Properly interpreted these displays also provide a visual image of the sound field. Such displays supplement, but do not replace, conventional bar graphs and Lissajous patterns that are still needed for detailed analysis or accurate measurements.

The data for the display is obtained by digitizing the audio from each channel, performing a correlation function between the audio channels of a stereo pair to obtain a correlation value, converting the correlation values to a graphic display according to the desired display function from among Figs. 1-9, adding the graphic images to the graphic display, and periodically displaying the graphic display on a suitable display device. The graphic display may be updated sixty times a second to provide an instantaneous display of the surround sound audio program. Peak values may be displayed as well, such as by using an arc segment at the inner ends of the wedges. The display is created from the amplitude of each channel, which is straightforward, and the computed correlation between the L & R and LS & RS channels. One correlation computation that may be used is the same as that used in the 764 Digital Audio Monitor manufactured by Tektronix, Inc. of Beaverton, Oregon as described in the accompanying User Manual. The amplitude data is processed in the same way as for a level meter, i.e., metering ballistics are applied. The correlation data also may be smoothed.

The present invention may be extended to any number of systems having different channels, such as the common 3/1 system (three front channels L, C, R and one surround channel S) simply by fixing the width of the rear wedges and using them both to represent the S channel. They might even be joined to become one wide wedge. The extensions may be from simple stereo systems to 7.1 channel systems.

Thus the present invention provides on a single display a representation of a surround sound field showing amplitude information for each channel and phase correlation between channel pairs by presenting a "sound stage" with speaker images and a listener, providing a correlation meter scale, either visible or invisible, for each channel of stereo channels, and providing markers that have an amplitude toward the listener representative of amplitude and a width representative of correlation or phase.